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Incidence of cancer among Finnish airline cabin attendants, 1967-92

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Abstract

Objective—To assess whether occupational exposure among commercial airline cabin attendants are associated with risk of cancer.

Design—Record linkage study.

Setting—Finland.

Subjects—1577 female and 187 male cabin attendants who had worked for the Finnish airline companies.

Main outcome measure—Standardised incidence ratio; expected number of cases based on national cancer incidences.

Results—A significant excess of breast cancer (standardised incidence ratio 1·87 (95% confidence interval 1·15 to 2·23)) and bone cancer (15·10 (1·82 to 54·40)) was found among female workers. The risk of breast cancer was most prominent 15 years after recruitment. Risks of leukaemia (3·57 (0·43 to 12·9)) and skin melanoma (2·11 (0·43 to 6·15) were not significantly raised. Among men, one lymphoma and one Kaposi's sarcoma were found (expected number of cases 1·6).

Conclusions—Although the lifestyle of cabin attendants is different from that of the reference population—for example, in terms of social status and parity—concentration of the excess risks to primary sites sensitive to radiation suggests that ionising radiation during flights may add to the cancer risk of all flight personnel. Otherwise the lifestyle of cabin attendants did not seem to affect their risks of cancer. Estimates of the effect of reproductive risk factors only partly explained the increased risk of breast cancer. If present estimates of health hazards due to radiation are also valid for cosmic radiation, then the radiation doses of cabin attendants seem too small to account entirely for the observed excess risk.

Introduction

Airline crews are occupationally exposed to cosmic radiation consisting mainly of neutrons and γ rays. The mean annual dose equivalent has been estimated as 1-3 mSv,[1] but it varies according to flight altitude, latitude, and solar activity. The most important determinant of the dose rate is altitude, with the dose doubling every 1500 m.[2] Some estimates of the potential health hazard due to radiation exposure have been published,[3] but so far no empirical studies on the risk of cancer among cabin attendants (members of cabin crews) have been conducted. We aimed at finding out whether occupational exposure among cabin attendants is associated with an excess risk of cancer, paying special attention to cancers related to radiation.

Subjects and methods

We identified all cabin attendants who had ever worked for the Finnish flight companies and had not died before 1 January 1967 from the files of the Finnair Flight Company. Recruitment started in the late 1940s, with the sharpest increase in the number of cabin attendants in the 1970s. The mean age at the start of employment was 24·0 years and the mean number of years of work (taking only partly into account the part time work and excluding maternity leave) was 8·3 years. Of the cohort members, 90% had more than two years and 34% more than 10 years of exposed work.

We searched the unique personal identification numbers (given to all residents in Finland since 1 January 1967) for all cabin attendants in the population register centre of Finland. We obtained the dates of death and emigration from the same source.

Follow up for cancer through the files of the population based, countrywide Finnish cancer registry was done automatically with the personal identification number as the key. The follow up for cancer started at the date of recruitment as a cabin crew worker or on 1 January 1967—whichever was later—and ended at emigration, death, or on 31 December 1992. No subjects were lost from follow up.

We counted the numbers of observed cases and person years at risk separately for three calendar periods (1967-75, 1976-84, and 1985-92) by five year age groups. We calculated the expected numbers of cases for cancer overall and for specific cancers by multiplying the number of person years in each age group by the corresponding sex specific average incidence of cancer in the whole Finnish population during the period of observation. We divided the subjects further, by time elapsed since recruitment and by time spent at work. In the latter case, the follow up started at the date when the person had been working the required time as a cabin crew member. The specific cancers selected a priori for the analysis comprised cancers related to radiation and other common cancers, to yield the whole picture of cancer among Finnish cabin attendants.

We calculated the standardised incidence ratio by dividing the observed number of cases by the expected number. The significance was tested by the Mantel-Haenszel χ^2 test, on the presumption that the number of observed cases followed a Poisson distribution.

Results

In all, 187 men and 1577 women were followed up. The numbers of person years were 2500 and 22 000 respectively (table I). The mean length of follow up for a person was thus 13·9 years. More than one third of the person years were in age groups below 30 years and few person years were in ages above 60. During the 25 year follow up period two cases of cancer (one non-Hodgkin's lymphoma and one Kaposi's sarcoma of the skin) were found among men (expected number 1·6). Another Kaposi's sarcoma was diagnosed in 1993, shortly after the end of the study. In women 35 cancers were found (expected number 28·4) (table II). The risks of breast cancer (standardised incidence ratio

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TABLE I—*Number of cabin attendants (%) traced in the census and person years at risk in 1967-92, by sex and age*

Age (years)*	Men		Women	
	Total No	Person years	Total No	Person years
<30	76	907	1437	17 [illegible]
30-59	51	1335	1430	19 227
≥60	[illegible]	[illegible]	10	1126
Total	187	2496	3577	37 974

*Age at beginning of follow up.

TABLE II—*Observed and expected numbers of cases of cancer and standardised incidence ratios (95% confidence interval) among Finnish female cabin attendants in 1967-92, by site or type of cancer*

Primary site or type	Observed	Expected	Standardised incidence ratio
All sites and types	35	28·4	1·23 (0·86 to 1·71)
Stomach	1	1·0	1·04 (0·03 to 5·78)
Colon and rectum	2	1·5	1·32 (0·16 to 4·75)
Lung (bronchus)	1	0·6	1·61 (0·04 to 8·95)
Breast	20	10·7	1·87 (1·15 to 2·23)
Cervix	0	1·0	0 (0 to 3·70)
Uterus	0	1·2	0 (0 to 3·00)
Ovary	1	2·1	0·47 (0·01 to 2·61)
Urinary organs	0	0·7	0 (0 to 7·39)
Skin (melanoma)	3	1·4	2·11 (0·43 to 6·15)
Nervous system	1	2·0	0·51 (0·01 to 2·86)
Thyroid gland	1	1·0	0·62 (0·02 to 3·42)
Bone	2	0·1	15·1 (1·82 to 54·4)
Lymphoma	1	1·1	0·91 (0·23 to 5·09)
Leukaemia	2	0·6	3·57 (0·43 to 12·9)

1·87 (95% confidence interval 1·15 to 2·23)) and bone cancer (15·1 (1·82 to 54·4)) were significantly raised. Non-significant excesses were obtained for leukaemia (3·57 (0·34 to 12·90)) and skin melanoma (2·11 (0·45 to 6·15)). The combined standardised incidence ratio for other sites, including the gastrointestinal tract, genitals, and urinary organs, was 0·5 (0·2 to 1·0).

All cases of breast cancer were diagnosed more than 15 years after the subject was recruited. The standardised incidence ratio was 3·4 (1·5 to 6·5) in the follow up category 15-19 years since recruitment and 2·1 (1·1 to 4·0) in the category ≥20 years. The standardised incidence ratio increased only slightly, however, with increasing time in exposed work: those with at least two years of exposed work had a standardised incidence ratio of 2·0 (1·2 to 3·2) and those with at least 10 years a ratio of 2·1 (0·9 to 3·9). All the cases of melanoma of the skin, bone cancer, and leukaemia were among subjects with at least two years in exposed work.

Discussion

Significantly raised risks of breast and bone cancer were observed among Finnish female cabin attendants. Breast cancer is one of the cancers most readily induced by ionising radiation. In studies of the incidence of cancer among survivors of the atomic bomb, the highest excess relative risk per unit exposure of all solid tumours has been observed for breast cancer (1·6 Sv^{-1} (95% confidence interval 1·1 Sv^{-1} to 2·2 Sv^{-1})).[1] The number of cases of bone cancer was small; thus, although significant, the finding may be attributable to chance. Furthermore, the bone cancers were not osteosarcomas—which are most commonly associated with radiation exposure—but one chondrosarcoma and one malignant chordoma.

Although the cohort consisted of all persons who had ever worked as members of a cabin crew in Finland, the size of the cohort was still so small and the age structure so young that the numbers of cancer cases were small and the risk estimates subject to large random variation. Identification of personal identification numbers of the cohort and the follow up for deaths and emigration were complete for the period of this study. Cancer registration in Finland is virtually comprehensive[2] and the computerised record linkage procedure precise.[3] Technical incompleteness has probably not therefore biased the results.

RADIATION EXPOSURE

The mean cumulative dose equivalent of cosmic radiation among cabin attendants was estimated as 15-20 mSv. On the basis of the estimates of the Committee of the Biological Effects of Ionizing Radiations[4] this would correspond to a relative risk of 1·01 for breast cancer (taking into account that the mean age at first exposure in this cohort was 24·0 years and the mean net duration of employment 8·3 years). The risk of breast cancer was most apparent after at least 10 years of work. Even in this category the cumulative radiation dose remained far below the level estimated to be required for the risk of breast cancer to double (0·6 Gy, estimated from Hiroshima and Nagasaki). Cabin crews, however, have a chronic exposure to neutrons, whereas the epidemiological risk estimates are based on studies of populations with acute exposure to sparsely ionising γ and x ray radiations. At the moment no epidemiological risk estimates of the cancer risk associated with exposure to neutron radiation exist. In experimental studies the relative biological effectiveness of neutrons relative to γ radiation in inducing tumours at low doses has been 10-100.[5] In addition, the effect of the dose rate differs from γ radiation: small dose rates have been as effective in inducing cancer as high dose ones—that is, there is no effect of the dose and dose rate effectiveness factor. Radon, another source of external radiation from high linear energy transfer, has an inverse dose rate effect—that is, small repeated exposures carry a larger risk of cancer than the same amount of exposure during a short period of time.

Recently, a comprehensive study of the risk of cancer due to occupational exposure to radiation among workers in nuclear power plants was published.[6] The risk estimates for both solid tumours and leukaemias were compatible with those derived from studies of survivors from the atomic bomb. A study of the incidence of and mortality from cancer among airline pilots found that pilots had an excess risk of cancers of the brain and rectum.[7] These populations consist, however, almost exclusively of men, and they are not relevant for assessing the risk of breast cancer associated with occupational exposure to radiation.

LIFESTYLE

Bias caused by non-occupational lifestyle factors is possible. Cabin attendants belong to a high social class, which in Finland has a higher than average overall incidence of cancer among females and a lower than average incidence among males.[8] Breast cancer is one of the cancers for which variation for social class is relatively wide: in 1981-5 the incidence of breast cancer among Finnish women of working age who came from the highest social class was 30% higher than in the average population.[9] If the expected numbers of cases of breast cancer is corrected by the standardised incidence ratio of Finland's social class I (the highest class) then the standardised incidence ratio is reduced to 1·4 (95% confidence interval 0·9 to 2·2). In the follow up group of ≥15 years since recruitment even the corrected standardised incidence ratio is significant (1·9 (1·2 to 2·9)).

Reproductive factors are the strongest known aetiological component of breast cancer and account for most of the occupational and social class variation in the incidence of breast cancer in Finland.[9] The reproductive data for individual cabin attendants were not available. Through the use of a database of Statistics Finland, however, some of the reproductive

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variables for cabin attendants and for the total Finnish female population in 1985 can be compared at group level. The proportion of nulliparous women aged ≥ 35 years was about 20% among cabin attendants, compared with 12% in the total female population. The average age at first birth in these two populations was 28 in the cabin attendants and 25 years in the total female population. The average number of children born to cabin attendants was in all age groups smaller than in the total population. With nulliparous women included in the numerators, cabin attendants aged 40–49 had on average 1·7 children and women in the total population had 2·7.

Both a Finnish case-control study[4] and an international meta-analysis[5] showed that postponement of the first birth by five years increases the relative risk of breast cancer by 20–30% and that having three children or more decreases the risk by one third compared with that of women with fewer children.[5] Age at first birth and parity acted independently as risk factors. Cabin attendants differ from reference populations mainly in the average number of children. Only 28% of the cabin attendants aged 40–49 had three or more children, whereas the corresponding figure for the total population was about 45%.

By using age at first birth and prevalence of women with at least three children and the estimated risk coefficients associated with these factors, the difference in relative risk attributable to reproductive factors between the cabin attendants and the reference population was 23%—that is, close to the excess attributable to belonging to social class I. Hence, even after the differences in reproductive and other factors related to social class are taken into account, a pronounced excess risk of breast cancer remains, which is significant, however, only 15 years after recruitment.

Interaction between radiation exposure and reproductive history with regard to the risk of breast cancer has been reported among survivors of the atomic bomb: the joint effect of radiation and reproductive risk factors for breast cancer acted in a multiplicative fashion—that is, the effect of the two types of risk factor exceeded the sum of the main effects.[6] With regard to our results, this would mean that for cabin attendants, who have a raised risk owing to occupational exposure to radiation, smaller number of births, and later age at first delivery, the risk of breast cancer attributable to these factors would exceed that derived from predictions if the two exposures were considered separately. With the small magnitude of risks, the contribution of a multiplicative term to the overall risk is, after all, negligible.

POSSIBLE CONFOUNDERS

Other risk factors may be associated with lifestyle that confound our results. Fat intake and alcohol consumption have been suggested as risk factors for breast cancer, but the empirical evidence remains scanty.[4] At the moment, we do not have data to assess the effects of these factors. Cabin attendants may differ from the general population with respect to alcohol consumption or diet. We found no indication, however, of increased incidence of types of cancer associated with these factors—for example, cancers of the oesophagus, larynx, and colon.

Skin melanoma is known to be associated with repeated sunburn, and people with white skin are at greatest risk. In Finland the fashion for a tan used to be most popular among people from the high social classes living in urban areas—most cabin attendants fall into this category. Two of the three cases of skin melanoma were diagnosed at the ages of 27 and 29, and the origin of these cancers was probably in the youth of these women before they started their cabin crew work. Flying to the south more often than the general population does not seem to increase cabin attendants' risk of melanoma.

Social class is not an important risk determinant of bone cancer or leukaemia, and furthermore the aetiology of these cancers is largely unknown. Radiation and viruses are the only sufficiently confirmed risk factors for both of these cancers, and radiation is present in the work environment of cabin crew. In the systematic calculation of occupation-specific cancer risks in Finland during 1971–85 cabin attendants were included in a larger category of stewards and stewardesses working on other forms of transport (mainly ships, trains, and buses). Their cancer risk could not therefore be studied separately, but pilots had the highest risk of leukaemia of all the occupations (standardised incidence ratio adjusted for social class 9·8 (95% confidence interval 1·2 to 35)).[4] Although this observation was also based on only two cases, it is in line with the hypothesis that all flight personnel may have an increased risk of leukaemia.

Two of the three cases of cancer in men were Kaposi's sarcomas, which is a rare cancer in Finland and is associated with AIDS. The excess risk of Kaposi's sarcoma is therefore probably not directly related to occupational exposures.

The concentration of the excess risks among cabin attendants in primary sites sensitive to radiation suggests that ionising radiation during flights may add to the cancer risk of flight personnel. Our findings, however, are based on small numbers of cases and need to be confirmed in other populations. On the basis of current theoretical estimates of risk of cancer that is induced by radiation, occupational exposure to cosmic radiation alone is unlikely to account for the excess risk of cancer, although the radiation exposure among cabin attendants substantially differs from that of survivors of the atomic bomb and of medically irradiated persons, on whom the risk estimates are based. Studies linking individuals' history of exposure and exact data on confounders to subsequent risk of cancer are required.

Key messages

- Airline cabin crews are occupationally exposed to cosmic radiation, and their lifestyle may also differ from that of the average population in other aspects
- The radiation dose of cabin attendants has been estimated as 2–3 mSv a year
- Female cabin attendants had a significant 1·9-fold incidence of breast cancer and a 1·5-fold incidence of bone cancer compared with the national average
- The excess of breast cancer can be partly explained by social class and reproductive factors, but even when these factors are taken into account a significant, an almost twofold risk remains in those who have worked for 15 or more years in their profession
- Observed risk ratios are much higher than would be expected on the basis of present estimates of health hazards due to radiation (based on survivors of the atomic bomb and on people occupationally exposed to γ radiation)

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Boice JD, Land CE, Shore RE, Norman JE, Tokunaga M. Risk of breast cancer following low dose exposure. Epidemiology, Prevention and Control. 1979;4:214–24.

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